FAO E-Forum on Full Cost Accounting of Food Wastage:
Week Three: Water Use

Week three of the E-Forum addresses food wastage impacts on water use and the related societal costs.

Food wastage impacts on water use

Phase I of the Food Wastage Footprint (FWF) project estimated that the irrigation water quantity ("blue water") lost due to food wastage amounted to 250 km^3 per year (FAO, 2013). These calculations have been further refined in Phase II by including water consumption from commodities that were not covered in phase I (e.g. sugar, coffee, alcoholic beverages). The inclusion of additional crops resulted in minor changes only.

Additionally, AQUASTAT was investigated as an alternative dataset to the Water Footprint Network (WFN) (Hoekstra, Chapagain *et al.*, 2011) used in Phase I.[1] Using AQUASTAT or WFN data produced results that are largely consistent. Blue water consumption results are about 20% lower using AQUASTAT, as opposed to WFN, but both data sets exhibit major uncertainties. For consistency, we will continue to use the original WFN data from Phase I for the full cost accounting.

FWF also provided some general illustration of how food wastage may contribute to water scarcity by displaying food wastage volumes and water scarcity levels per region. Water scarcity is defined as "an excess of water demand over available supply" (FAO, 2012). The water use of food wastage adds to water scarcity as it increases the demand in relation to the available supply thus increasing the potential for excess demand. Croft, Dawkins *et al.* (2013) derived country-wise scarcity values based on an assessment on how much water is extracted from the total run-off in major river-basins, taken from Hoekstra, Mekonnen *et al.* (2012). If this extraction exceeds 40%, it is labelled a situation of severe water scarcity. In each country, the areas of the basins that face severe scarcity over the year are then put in relation to the total area of river basins in this country, thus resulting in an indicator of water scarcity in that country. Given this national water scarcity measure, the impact of food wastage on water scarcity could then be addressed in an approach that is similar to the one used for deforestation; the areas facing severe water scarcity being put in relation to irrigated areas used for agricultural production (and to the irrigated areas behind the volumes of food wasted).
A first step will be to access this scarcity data, currently not publicly available, to estimate the contribution of food wastage to water scarcity. Any suggestions for alternative approaches are most welcome.

Social and environmental costs of water use

Following expert recommendations, we intend to use a Total Economic Value (TEV) framework to evaluate water costs (Martinez-Paz and Perni, 2011). The TEV framework helps to distinguish between different use values (cf Figure 1):

- ***Direct use value***, including consumptive and non-consumptive use value. Irrigation is the most significant direct consumptive use (in terms of volume), and can be estimated by the cost of extraction or from market costs adjusted to account for subsidies. Examples of non-consumptive direct use value include recreation or hydro-electric power generation.

- ***Indirect use value***, including the range of ecosystem services that water provides. These include regulating services (ecosystems processes such as water purification) and supporting services that underpin ecosystems (e.g. habitat). These services could not be provided by streams/wetlands that are disrupted as the natural rate of flow is reduced.

[1] AQUASTAT reports blue water consumption per ha of irrigated area, while WFN reports blue water consumption per ha of total cropping area. Consequently, using WFN data results in lower consumption per ha, but with a larger reference area. Comparing results using these two data sets and the corresponding land areas (total area harvested for the WFN data and area with irrigation equipment for AQUASTAT), they are largely consistent.

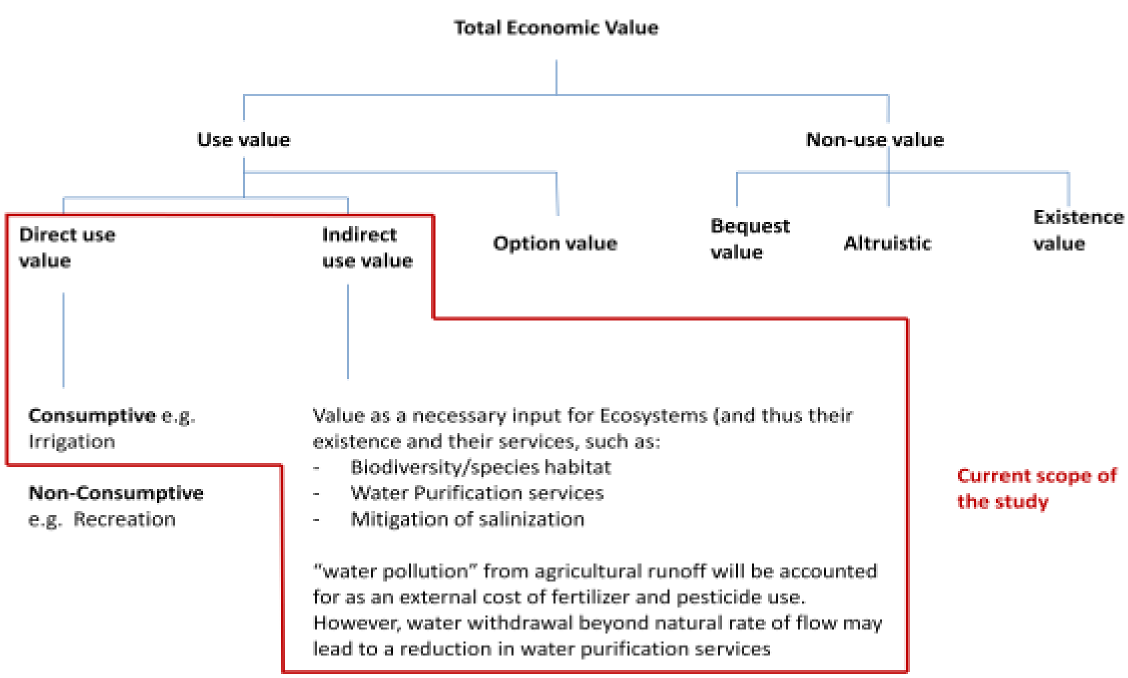
- ***Option value*** accounts for the potential future benefits received from the environment.

- ***Non-use values*** include e*xistence value* (derived from knowing that something exists), *bequest value* (leaving something for future generations), and *altruistic value* (derived from knowing that others use the resource)

To evaluate the value of water we will first look at some external costs (level one of the FCA framework[2]) and then try to estimate the effect of water consumption on scarcities (level two of the FCA framework). Downstream non-consumptive use values (recreation and ecosystems services) can be considered as additional to the consumptive use value of irrigation, as blue water consumption implies water lost from the water cycle.
As a starting point, we will estimate the value of irrigation water use and then add some non-consumptive uses. Ideally, we would account for upstream and downstream uses separately (as upstream non-consumptive uses, prior to extraction, are not lost). However, this introduces some difficult complications about where in the water cycle different activities take place.
Furthermore, a distinction should be made between water consumption and water pollution. The costs of water pollution from agricultural runoff are not directly related to water use. Water pollution damages (e.g. eutrophication) need to be linked to the source of the pollution (fertilizer and pesticide quantities used), or the total area of agricultural land as a proxy.

Through our initial literature review, we found an extremely wide range of values for non-consumptive values such as recreational use and non-use values such as existence value. These uncertainties reflect the dependence on a range of strong assumptions that have to be made for determining such values, resp. on the local and regional character of such estimates (e.g. depending on the people surveyed for a contingent valuation study). Thus, these values are particularly difficult to generalize with the help of benefit transfer and we therefore refrain from further investigating those. As a first step, we rather suggest focusing on valuing the direct use value (irrigation) and indirect use value (ecosystems services) of water to estimate level 1 costs.

Figure 1: Total Economic Value of Water



[2] http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/FWF_E-Forum_Working_Paper.pdf

Draft approach to water use monetization

Irrigation costs: As a first step we estimate the cost of blue water irrigation based on the food wastage water footprint data available in FWF Phase I. The literature on irrigation costs revealed a range of values from reported irrigation costs.[3] We have only included best quality data available – more uncertain values for specific countries have been excluded. The upper end is $0.25/m^3$ charge in Bangladesh, corresponding to roughly $5/m^3$ in the UK (employing benefit transfer). The lower end is a value of 0.01$/m^3$ in the UK. Using benefit transfer to derive values for all countries results in a range of 0.56 to 280 billion US$. This assessment can be improved by transferring values only to those with similar regional and socio-economic context (rather than to all countries). Results will then likely be towards the lower end of the distribution. Based on the available data, we expect some result in the range of approximately $10-50 billion, but final numbers can only be provided after having done the relevant calculations in detail.

There are a number of further difficulties:

- There is major spatial (both between and within countries) and seasonal variation in prices. This variance is disguised by average prices.
- Cost recovery is usually restricted to operating and maintenance costs and rarely includes a small portion of initial capital costs. Furthermore, collection efficiency is not accounted for (for some studies, values on this are available). The estimates provided are thus low estimates as they are based on a part of the full irrigation costs only.
- Formal charges do not capture the full water payments made by farmers through extra-legal payments, contribution of labour and additional on-farm costs. On the other hand, not all officially estimated costs represent real costs (e.g. possibly due to overstaffing, poor management and corruption).
- Water fees are generally insufficient to cover operation and maintenance expenses in developing countries. Many countries also face difficulties in collection efficiency. OECD countries are more likely to cover 100% of operating and maintenance costs.
- Groundwater schemes (in Spain at least and probably as a general rule) are largely driven by market forces. Private entrepreneurs take the risk to invest in infrastructure and costs are borne by farmers. In contrast traditional surface water schemes are heavily subsidised by governments.

Besides reported irrigation costs, non-market based cost estimates could be used, e.g. based on opportunity cost estimates. Examples of this are given in Dachraoui and Harchaoui (2004), Garrido, Martinez-Santos *et al.* (2005), Samarawickrema and Kulshreshtha (2008), Martinez-Paz and Perni (2011) and results from those studies are also in the cost range reported above.

Ecosystem services: A next step would be to use non-market valuation for determining the costs of water use due to food wastage on ecosystem services. Part of this can be covered under the water scarcity costs considered further down, as negative impacts on downstream ecosystem services can, for example, accrue to increased scarcity due to water extraction (e.g. the effect of irrigation on the Lake Aral). Other aspects, however, such as water purification services, need not be affected in a context of scarcity only. Indirect use values can be determined by a range of approaches, e.g. opportunity cost estimates or by willingness-to-pay surveys. The latter, however, tend to cover the whole range of ecosystem services, including non-use values, as they often aim at identifying the willingness-to-pay for conservation of the ecosystem as a whole, including all its services. Martinez-Paz and Perni (2011), for example, find a value of about 0.09 $/m^3$ for the services of wetlands in Spain, based on willingness-to-pay studies per person multiplied with the relevant population and divided by the total amount of water used. This is in the range of the direct irrigation cost estimates reported above.

Environmental non-market valuation also presents a range of further challenges:

- Non-market valuations depend on the type and quality of the ecosystems being valued and thus are highly dependent on local conditions. Getting a representative or average value is a challenge.

[3] Data is mostly based on FAO (2004), Garrido, A., P. Martinez-Santos and M. R. Llamas (2005), Ghazouani, W., Molle, F. and Rap E. (2012)., Quershy, M. E. *et al* (2007) and Solbes, R. V. (2003).

- Estimating the environmental non-use value is often based on willingness-to-pay surveys and thus expressed as a value per person, e.g. (Ojeda, Mayer *et al.*, 2008). Results then depend on the authors' judgements about the relevant population (Martinez-Paz and Perni, 2011). We suggest using such per person values in combination with some consistent assumptions about the relevant 'local' population that benefit from ecosystems services provided by water – a key question is however how to apply benefit transfer to such values.
- As outlined above, whether ecosystems services are provided upstream or downstream from the point of extraction is significant.

Water scarcities: For the valuation of water scarcity due to food wastage, we suggest to follow the approach used in Trucost (2013), based on a relationship between water value and water scarcity. The function used in Trucost (2013) is not presented in their report, but we are attempting to get further details on it. Any suggestions on such "scarcity cost functions" are most welcome. Another approach would be to use scarcity values as estimated in local and regional studies, such as for California (Jenkins, Lund *et al.*, 2004). As with ecosystem services valuation, benefit transfer to other cases is also a big challenge.

Questions for Discussion

- What is the best way to use irrigation values from different countries to undertake benefit transfer to arrive at global estimates? We need to know which countries are best comparable regarding irrigation costs, or on basis of which criteria this comparability may be established.
- Given that groundwater schemes likely are market driven, is there a case to only focus on groundwater schemes to avoid market distortions associated with surface water schemes? Are there cost estimates of the full cost of irrigation available? Accounting for full maintenance costs and for irrigation related on-farm labour cost, for example?
- We are also interested in data on non-market valuations of irrigation costs – Do you have any suggestions for data on this?
- How is benefit transfer best used with non-market valuations, where the type and quality of ecosystems and the relevant population play a key role? Is it at all possible to sensibly apply benefit transfer to these cases? How to best generalize results from local and regional studies?
- In water scarce countries, part of the scarcity value will be realized in the market price. One of the ideas from earlier consultations was to somehow tie the market price to a water scarcity index, e.g. via a regression. Would this be a promising approach to identify the part of the costs that relate to water scarcities?

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